Work

- Work is done by a force on an object only if the force is parallel to the direction of motion.

Work = Force times Distance moved

- W = F d

- The unit for work is the Joule (J) which is equivalent to Newton ´ meter

1 J = 1N m = 1 Kg m^2 / s^2

1. Which of the following is not an energy unit
   A. N·m B. Joule C. Calorie D. Watt E. kWh

2. A brick slides across a horizontal rough surface and eventually comes to a stop. What happened to the kinetic energy of the brick?
A. Nothing, it is still in the brick but is now called potential energy.
B. It was converted to other energy forms, mostly heat.
C. It was converted to a potential energy of friction.
D. It was simply destroyed in the process of stopping

A 20 N ball and a 40 N ball are dropped at the same time from a height of 10 meters. Air resistance is negligible. Which of the following statements is accurate?
A. After 1 second has elapsed, both balls have the same kinetic energy since they have the same acceleration.
B. The heavy ball has a greater acceleration and falls faster.
C. The light ball has a greater speed since it can accelerate faster than the heavy ball.
D. Both balls hit the ground at the same time but gravity does more work on the heavy ball than on the light ball.

Which has the greater kinetic energy - a 1-ton car moving at 30 m/s, or a half-ton car moving at 60 m/s?
A. a 1-ton car B. a half-ton car
C. both have same kinetic energy

Kinetic Energy

- Kinetic Energy exists whenever an object which has mass is in motion with some velocity. Kinetic energy is the energy of motion.
- Everything you see moving about has kinetic energy.

$$\boxed{\text{Kinetic Energy} = \frac{1}{2}\text{mass speed}^2}$$

$$\boxed{\text{KE} = \frac{1}{2}\text{mv}^2}$$

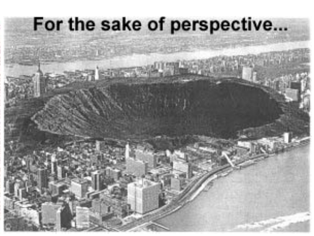
- Unit for Kinetic Energy is Joule (1 J = 1 Kg m^2 / s^2)

Kinetic Energy (cont.)

- A meteor of mass $m = 3\times10^8 kg$ and a velocity of 18000 m/s has a kinetic energy of

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}(3\times10^8)(18000)^2 = 5\times10^{16} J$$

- 50000 years ago this happened in Arizona



Gravitational Potential Energy

- The energy stored in a gravitational field, for instance by an object raised against gravity.
- The gravitational potential is related to an object's **position**.
- The gravitational potential energy stored in an object of mass m at a height h is:

$$PE = mgh$$

where g is the gravitational acceleration.

- Unit for Potential Energy is Joule (J).

Reference Levels for Gravitational Potential Energy

- A location where the gravitational potential energy is zero must be chosen for each problem
  - The choice is arbitrary since **the change** in the potential energy is the important quantity
  - Choose a convenient location for the zero reference height
    - often the Earth's surface or ground level
    - may be some other point suggested by the problem
  - Do *not* change the zero height location while solving the problem

Law of Conservation of Energy

- **Energy is conserved, it can change form but neither created or destroyed.** Energy can be converted from one form to another, but the total amount of energy is conserved.
- Example of energy "converters":
  - **Light bulb** converts electrical energy to radiant energy
  - **Car engine** converts the fuel chemical energy to kinetic energy
  - **Elevator** converts electrical energy to gravitational potential energy
  - **Hydroelectric dam** converts the water gravitational potential energy to electric energy

Law of Conservation of Energy (II)

- In isolated system, energy cannot leave or enter the system, therefore the total energy of the system is constant:

  Total Mechanical Energy=constant

  Kinetic Energy + Potential Energy=constant

$$KE + PE = \text{constant}$$

  - As an object falls, gravity converts potential energy into kinetic energy
  - As an object rises, kinetic energy is converted into potential energy

Law of Conservation of Energy (III)

- **Total Mechanical Energy is constant** or the sum of kinetic and potential energy is constant and can be written as:

$$KE_i + PE_i = KE_f + PE_f$$

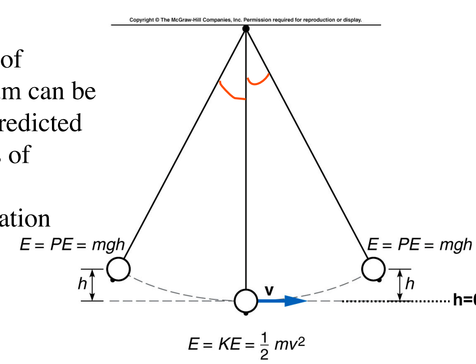
- Choose a convenient location for the zero reference height. Do *not* change the zero height location while solving the problem

Conservation of Energy

- Energy is conserved, it can change form but neither created or destroyed.
- As an object falls, gravity converts potential energy into kinetic energy
- As an object rises, kinetic energy is converted into potential energy
- An engine turns heat or chemical energy into kinetic energy
- Kinetic friction turns kinetic energy into heat

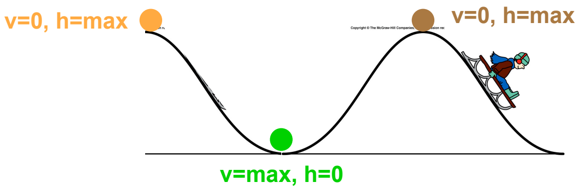
Pendulum Demo

- Motion of pendulum can be easily predicted in terms of energy conservation



Wave Track Demo

- Total mechanical energy is conserved



- You can find velocity at any height using KE+PE=constant

Momentum

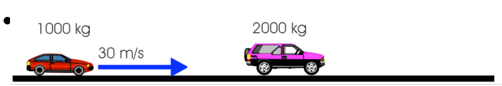
- According to Newton's second law
- Force=(mass) x (rate of change in velocity)
- Which is the same as saying that
- Force=Rate of change [(mass) x (velocity)]
- mass x velocity which represents the "quantity of motion" is called momentum
- Momentum is a vector quantity; it has both a magnitude and direction

$$p = mv$$

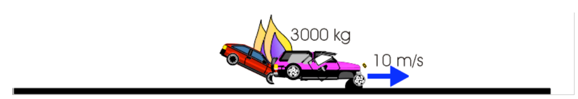
Momentum (cont.)

- Newton's third law means that if two objects interact with a force then they exchange momentum
- The amount of momentum in a system of objects is thus conserved

Momentum (cont.)

- Consider the following collision were the two cars stick together:
- 

- After P=30000 kg m/s so v=P/m =
- (30000kg m/s)/(3000 kg)=10 m/s



Impulse

- If a force F acts on an object for a time t then the impulse is defined to be the forceXtime.

$$I = Ft$$

- Since a force represents the rate at which momentum is transferred to an object; the impulse is the change in momentum.

$$P_f - P_i = mv_f - mv_i = I = Ft$$

- For instance if a force of 5 N acts on an object, it transfers a momentum of 5 kg m/s to the object per second.

Impulse (cont.)

- Consider a car with mass=1000kg moving at 20m/s which wants to break